# CIAT Uganda Regional Bean Breeding program

PABRA
Pan-Africa Bean Research Alliance
*Better Beans for Africa*

CIAT 50
1967-2017

8th April, 2018

CIAT MUKANKUSI, Bean Breeder and CIAT Country Director c.mukankusi@cigar.org

# Suggesting an alternative lay out

- An introduction of the PABRA program and participating projects – Slide from Envira ( Robins pool) at least 5 slides not more than 7 slides
- How does the Uganda CIAT office contribute to the PABRA aim for 3 slides each section. Introduce the pool of scientists and staff in Kawanda.
- Then you talk about breeding, different people can say what they do when their slides pop up or else you say it for all

Breeding slides, Impact assessment slides & Monitoring and evaluation slides

Human resource management slides, Logistics slides,

## Objective of PABRA'S Breeding Program

To develop market demanded resilient bean germplasm (adapted to fluctuations and extremes of climatic, edaphic factors, pests and diseases) and maintain stable bean production and quality in the presence of diverse stresses; enhancing the capacities of the communities to cope with stresses

CIAT Uganda responds to this objective to support the ECABREN and WECABREN

Three breeding sites: Kawanda, Kachwekano, Kagera

# CIAT Uganda Bean program Staffing

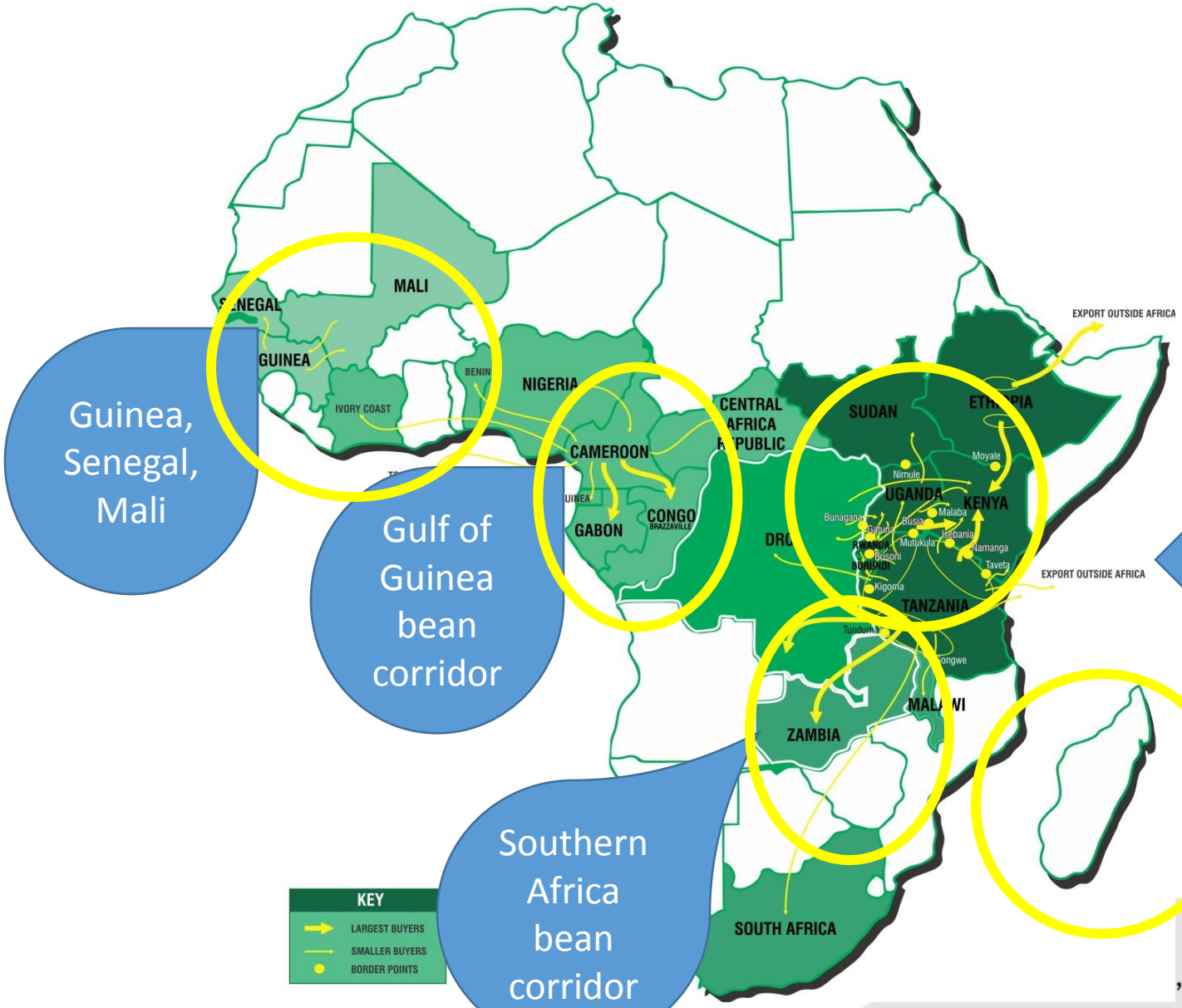
- Uganda: Three scientists (Plant breeder, Agricultural economist/impact assessment, M&E specialist)
- PABRA: Nutritionist (Nairobi), Market specialist (Rwanda), Agronomist (Nairobi), Seed system specialist (Tanzania); Gender specialist (Nairobi)
- CIAT Global: Molecular Genetist/Breeder, Senior Breeder
- Support Staff (Research): Research Associates: Plant pathologists 1, Plant breeder; 1, Agricultural economist; 1, Database officer; 1); Research Assistants (Molecular biologist; 1); Technical Assistants (Plant pathology/plant breeding; 6); Casual laborers >20 (wages)
- Support staff; Human Resources, Executive secretary, Finance officer, Accountant, Drivers (3), Lab cleaner, Security guard

# PABRA Bean Corridor Approach

- >90% of bean trade in East and Southern Africa is informal
- 60% of traders have access to information on bean prices
- Intensification of economic development is underway, for example the Southern Agricultural Growth Corridor of Tanzania (SAGCOT)
  - However, persistent systemic failures hinder smallholder involvement across the value chain, e.g.
    - cross-border trade restrictions
    - low tradable volumes
    - high transaction costs

# Mapping (Dry) Bean Corridors in Africa

***Major flows of beans from production to consumption area connected by distribution networks***




Guinea, Senegal, Mali

Gulf of Guinea bean corridor

East African bean corridors

Southern Africa bean corridor

Madagascar bean corridor

, a sustainable food future

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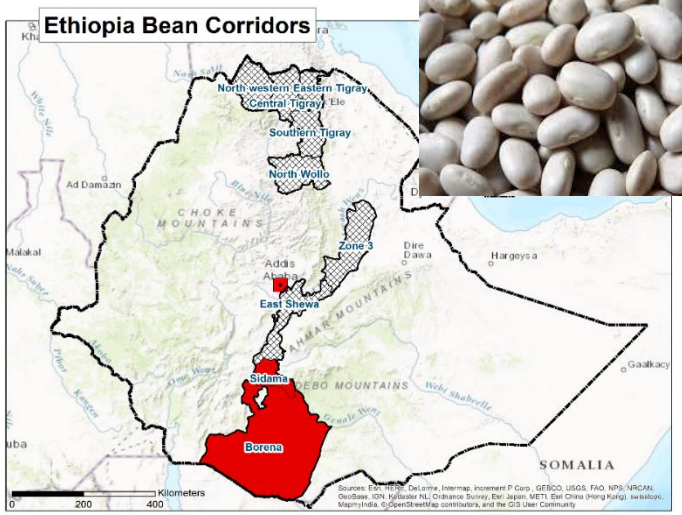
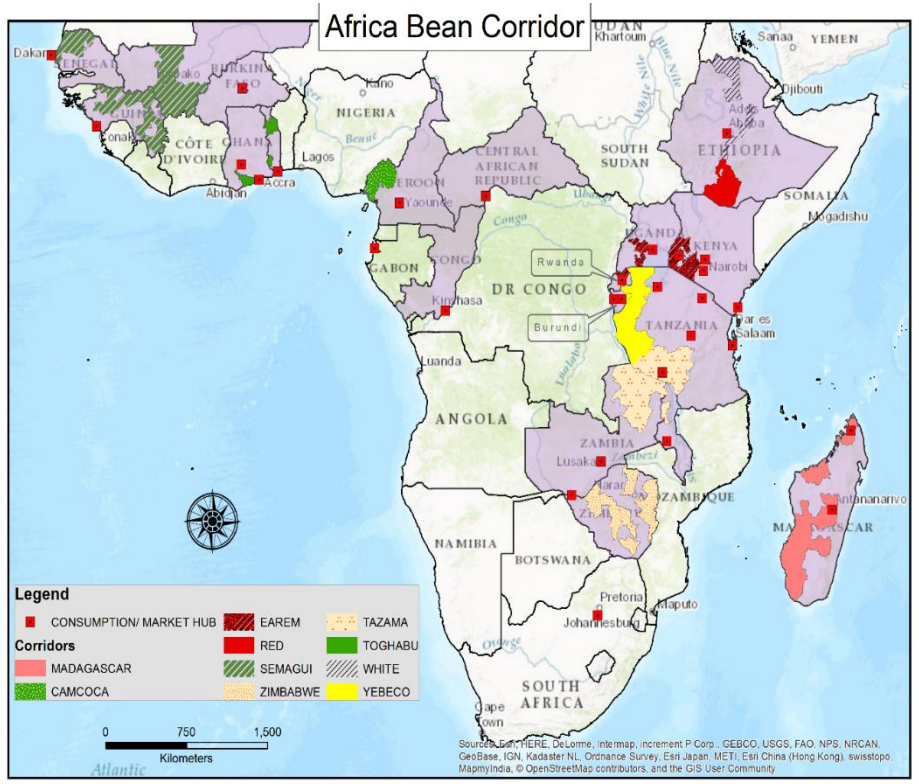
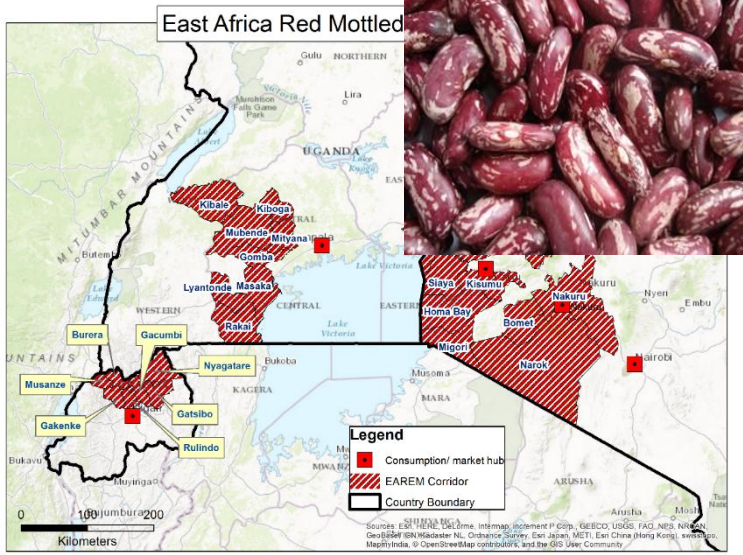
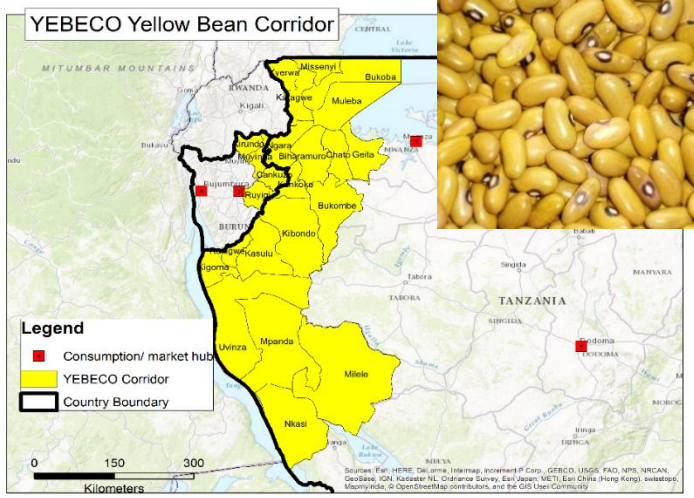
# East Africa Bean corridors





Our vision, a

# Opportunities of the Corridor Approach to Bean Breeding

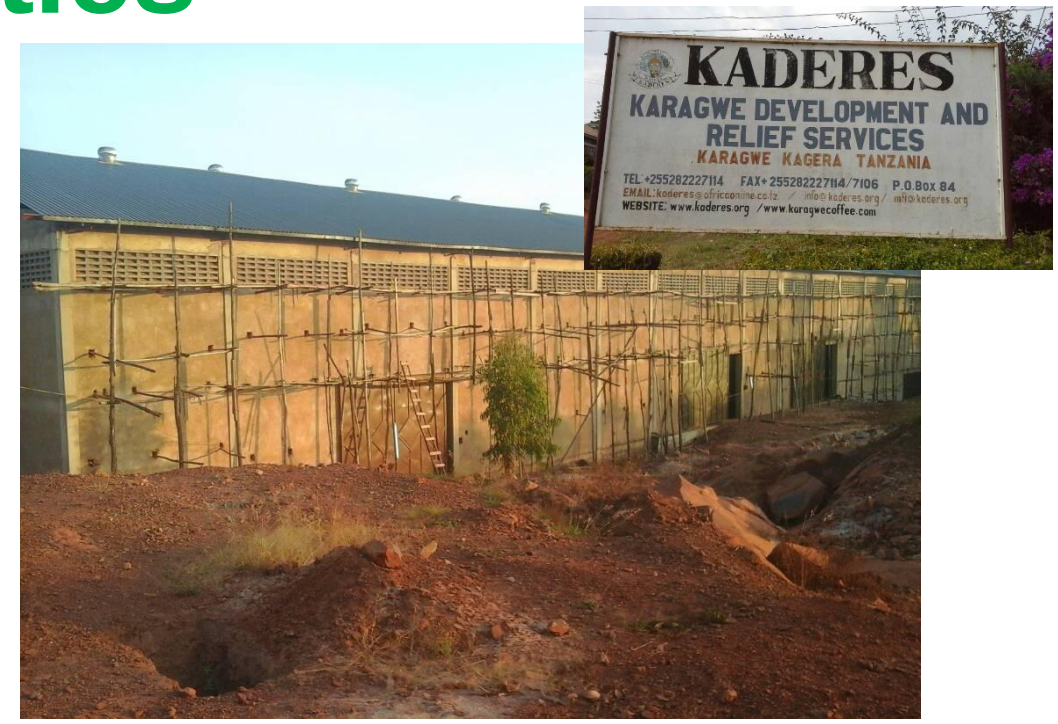
- A promising new development framework to create market-driven, rural agricultural transformation

- Focuses on improving the 'bean flow'

**Production** → **Distribution** → **Consumption**

# Opportunities

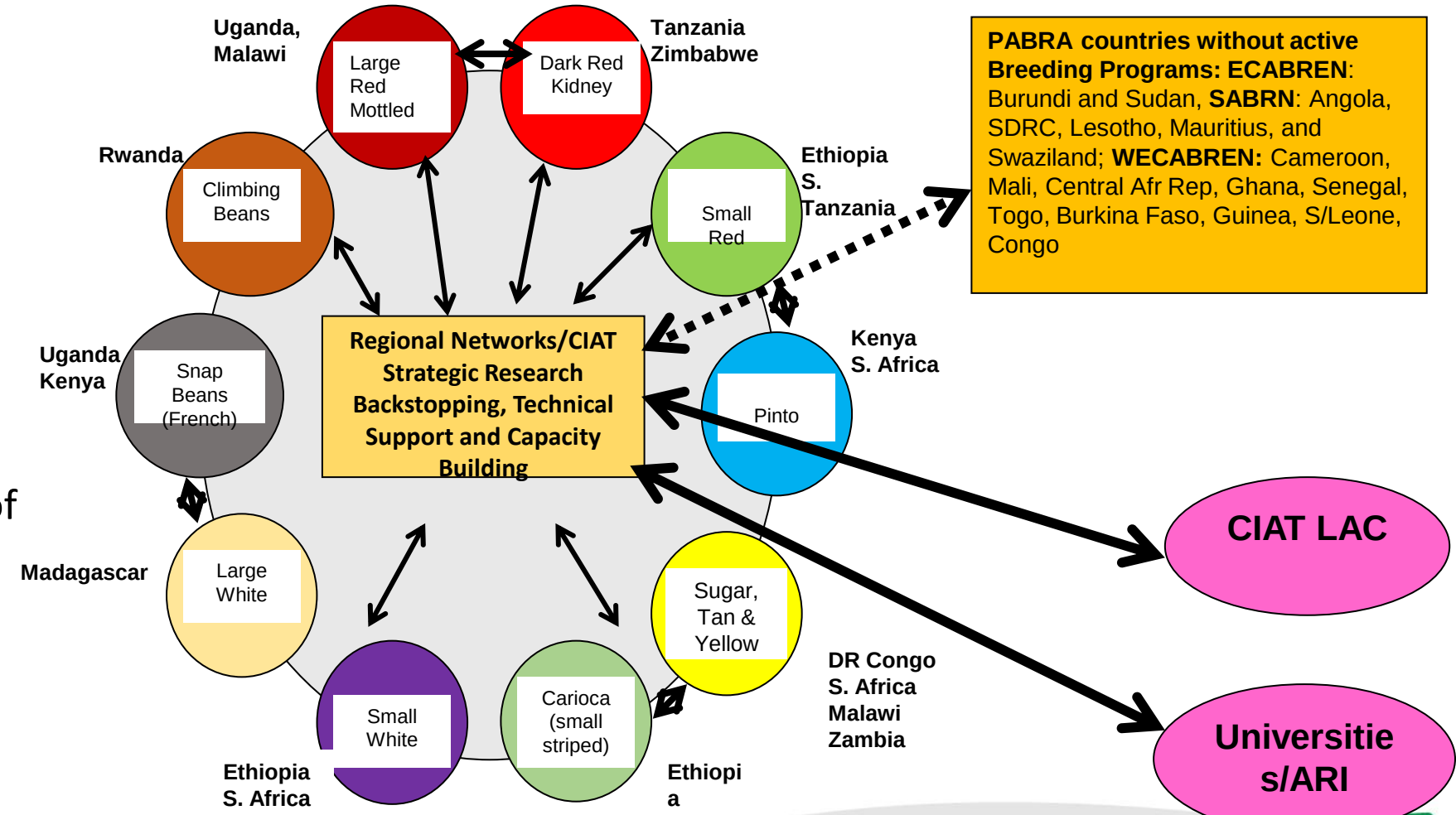
- Helps to better target varieties
- Offers opportunity of linking smallholder farmers to major local regional and international markets
- Stimulates growth of diverse business opportunities in seed, grain, processing, financial products, information among others




# BREEDING APPROACH

Shared breeding responsibilities under PABRA:

- CIAT Headquarter breeding program in Colombia
- Regional breeding programs of ECABREN and SABRN
- National bean programs responsible for different types of beans
- Various universities and advanced research institutes (ARIs).



# CIAT Ugand breeding activities

- Targets seven grain market classes:
  - Red mottled,
  - Small reds
  - Large reds
  - Small whites (navy)
  - Large whites
  - Sugar beans
  - Yellow beans

| Market class | Countries where the bean types are of high or moderate importance |
|---|---|
| A1. Red Mottled | UG, KE, DRC, TZ, SU, MD, BU, ET, RW |
| AII. Reds | |
| AIIa. Large Red Kidneys | TZ, KE, RW, MD, ET, BU, UG, DRC |
| AIIb. Small and Medium Reds | ET, KE, TZ, RW, DRC |
| III. Browns | |
| IIIa. Yellow | BU, DRC, RW, TZ, KE, UG, MD |
| IIIb. Brown | BR, DRC, RW, TZ, KE, MD |
| IIIc. Tan/Khaki | TZ, DRC, RW, UG, RW |
| IV. Cream | |
| IV a. Pinto | KE, UG, MD |
| IV b. Sugars | UG, DRC, ET, KE, RW and BU |
| IV c. Carioaca | KE, TZ, DRC, and MD |
| V. White seeded | |
| Va. Navy (Cam, DRC) | ET, RW, KE, CAM, DRC, and MD |
| Vb. Large white kidney | MD, DRC, ET, RW, CM and TZ |
| VI. Mixed Colours/others | |
| VIa. Purples/ Mwezimoja types | TZ, KE and MD |
| VIb. Blacks | DRC, UG, KE, TZ, SU and MD |

# Breeding priorities: Multiple trait breeding approach

**Resilience/cross cutting**

- Drought tolerance
- Low Soil fertility tolerance
- Resistance to existing and emerging pests and diseases

**Biofortification**

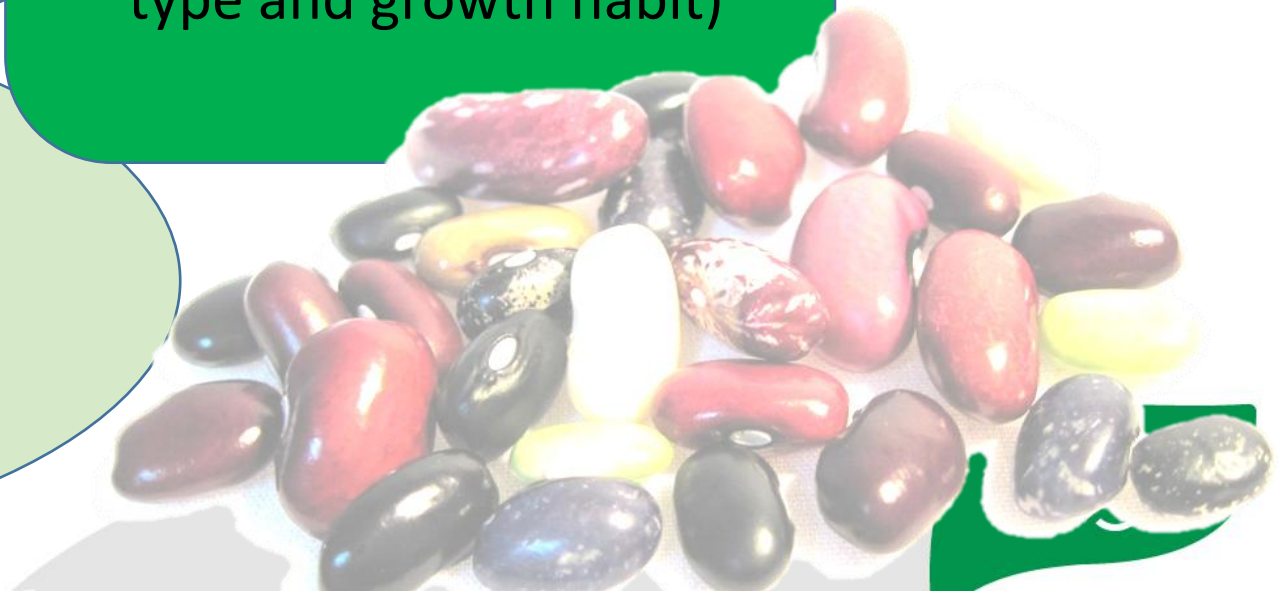
- High minerals content (Iron and Zinc), protein content & quality

**Consumer traits**

- Canning quality
- Snap bean quality
- Precooked quality
- Premium priced/demanded grain types
- Cooking time

**Must have traits**

- Productivity (high yield)
- Consumer preferences (e.g. acceptable grain type and growth habit)



# Trait Discovery

- Identification of new sources of traits (studying genetic mechanisms of trait inheritance)
  - Key diseases (anthracnose, common bacterial blight, bean common mosaic virus, root rots; Fusarium ,Sclerotium, Rhizoctonia and Pythium,
  - Major field pests (Bean stem maggot)
  - Fast cooking time
  - Canning quality
  - Drought tolerance (natural environment)
- Molecular breeding
  - Identification of new markers tagging identified resistance
  - Diversity studies (Pathology and breeding)
  - Marker assisted  selection (selection of parents)
  - DNA fingerprinting-Sample preparation (LGC)
  - GBS-DNA extraction and shipping (Elshire's lab, Cornell, IGSS)

# Breeding Pipelines; Bush and climbing bean breeding lines for drought tolerance and high mineral content

- 16 populations: drought tolerance advanced to F5/F6 with SSD
- 23 populations: fast cooking time advanced to F4 with SSD
- 11 climbing bean populations: bc3 introgression into high background
- 21 populations: drought & low soil fertility tolerance advanced to F4/F5 seed with SSD
- 38 new single crosses for combination of traits; yield, canning quality, high iron and zinc, short cooking time and bruchid resistance conducted February, 2018
  - Two, three and four way crosses within 2018 to make a total of 80 unique crosses

# Evaluation of fixed lines developed for drought, low soil fertility and drought tolerance:

- Eight hundred and fifty (850) lines developed for drought tolerance (from Cali); evaluated at Stage 1 and 2
- >500 lines for high Minerals and Drought evaluated
- 50 lines for low soil fertility (BILFA and BFS

# Breeding Pipeline 2: Bush and climbing bean breeding lines with heat and/or drought tolerance

- Initial stages
- Two sets of VEF lines(88 lines and 264 lines) from CIAT, Cali
- VEF 1 evaluated at Kawanda together with 12 superior lines selected from existing nurseries
  - 54% better than yield check CAL96
  - Best yielding : BFS 81, SEC 70, BFS 27, ALB 252-13, SCR 80, SCN 22, SMC 220, SMC 216, NCB 226, SMC 221 and SCN 24.
  - Seed Fe: 48.3ppm (BFS 81)-109.2ppm (SMC 214)
  - Seed Zn: 27.3ppm -41.6ppm: SMC 214, SEC 85, SEC 65, SMC 212 and SEN 118 Zn>40ppm.
- VEF2 included 36 lines coded SEF (improved for heat tolerance) in PYT 1 in 2017B. Total yield ranged from 2807.2 to 5825.0 kg/ha with a mean of 4062.9 kg/ha. Nursery shared with Tanzania, Ethiopia and Uganda National programs

# Breeding pipeline 3: Bush and climbing bean breeding lines for insect pest and disease resistance

- 23 populations: CBB resistance advanced to F5 with SPS.
- 12 populations: BSM and root rot resistance advanced to F2.
- 12 populations resistance to ALS through gene pyramiding advanced to F5/F6 with SSD
- 1060 lines selected from CBB populations.
- Four populations; CBB, ALS and high Fe developed

# Evaluation of fixed lines developed for Pest and disease resistance

- 38 lines resistant to Fusarium root rot and 14 resistant to Pythium root rot from 304 ADP
- Fifty seven (57 ) lines selected from set of 94 Fusarium root rot resistant (KFRR) lines.
- Yield of 2725.6kg/ha (Kawanda) and 2066.5 kg/ha (Kachwekano) of 144 lines selected from SSD population (MLB-49-89A x CAL96) of 300 lines.
- Two lines; ACC 10 and ACC 15 CBB resistant lines selected from 43 lines
- 84 lines (KARP) selected from a set developed for dual and durable resistance to bean anthracnose and root rots resistance

## Institutional capacity

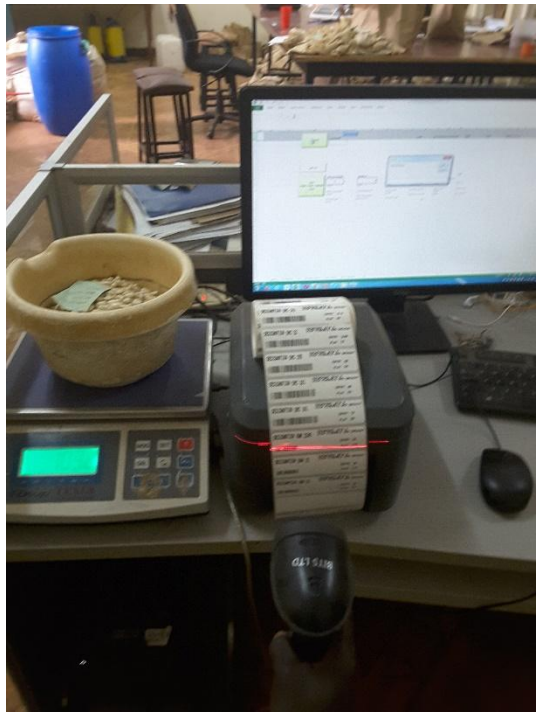
- Qualified breeder
- Pathologist support (not anymore)
- Seed systems support: Jean Claude Rubyogo, has more than 20 years of relevant experience in seed systems and diffusion studies
- Nutrition and acceptability studies are led by Dr. Mercy Lung'aho who works closely with Nutrition contact persons in the bean programs
- Two PhD students and three MSc students from Makerere
- RA breeder (MSc), 1 RA–Biotechnology (BSc), 2 RA pathologists (MSc); one left, 1 senior technician, 3 technicians, and 2 assistant technicians in dry bean breeding at Kawanda
- The support staff have extensive experience and training. Six support staff are fully trained in BMS and are using this tool. Continuous training offered by CIAT

# Key Findings - Positive Institutional capacity

- Clare coordinates the PABRA breeding efforts and has excellent connections to all of the national programs in ECA.
- Clare and Rowland Chirwa (dry bean breeder Malawi) share coordination and efforts in WCA.
- Dropbox extensively used to backup and share information globally. Although the system is good, it is not the same as a global database that can be mined efficiently.
- For released varieties, CIAT has an excellent global database for characterization. However for unreleased lines, characterization is in Excel only. The tool should be expanded to include unreleased lines.
- Uganda National Program, NARO, has extensive facilities and staffing at both at Kawanda and Namulonge in Uganda. CIAT program interacts routinely with these NARO staff and NARO avails research facilities to CIAT on request

# Positive Findings - Research facilities

- Seed Storage: The cold store (160 SQMT) is well-organized with stable temperature (15°C) and humidity capable of maintaining viability for more than 2 years
- Labels and barcodes are used for seed produced in 2014.
- Accurate seed inventory information exists in BMS
- Three mesh houses with about 500 SQMT are used extensively by the CIAT program in Kawanda.
- Fields
- Pathology and biotechnology lab



# Negative  Findings and recommendations

| Negative finding | Recommendation | Action taken |
|---|---|---|
| **Field variability is poor at the Kawanda station.** | CIAT needs to purchase a land leveler, disc and harrow for Kawanda. A tractor has already been ordered. | Tractor, disc and harrow purchased. Leveler to be purchased before December    |

| Finding | Recommendation | Action |
|---|---|---|
| **Uganda program currently only accomplishes two generations per year.** | To accomplish 3 generations per year, increased work space and drying equipment is needed to reduce time between harvest and replanting.<br><br>This nursery needs to be at a location warmer and dryer than Kawanda.<br><br>Irrigation equipment is needed. | Movable Drying shade acquired<br>Considering a site in northern Uganda<br>Irrigation facility acquired<br>Four generations currently achieved<br>  <br>  <br>  |

| Finding | Recommendation | Action |
| --- | --- | --- |
| **Program creates about 100 new populations annually. Moderate selection is exerted during inbreeding generations generating approximately 15,000 F5 lines. These are evaluated visually to select about 400 for entry into yield trails** | To fulfill the needs of 7 or more market classes and climbing versus bush beans, the number of populations created annually should double | Steps have been taken to have at least 50 new crosses targeting specific traits in specific markets classes each year<br><br>Currently over 2000 lines in yield trials |

| Findings | Recommendations | Action |
|---|---|---|
| **Currently about 5 different PYTs are evaluated annually with an average 80 new lines in each (up to 400 lines are evaluated). Selection intensity from the current PYTs is low (50%) to minimize reduction of genetic variability needed in various agro climactic zones** | The number of entries in PYT should be increased at least 100%. | To date number of PYT's have been tripled |

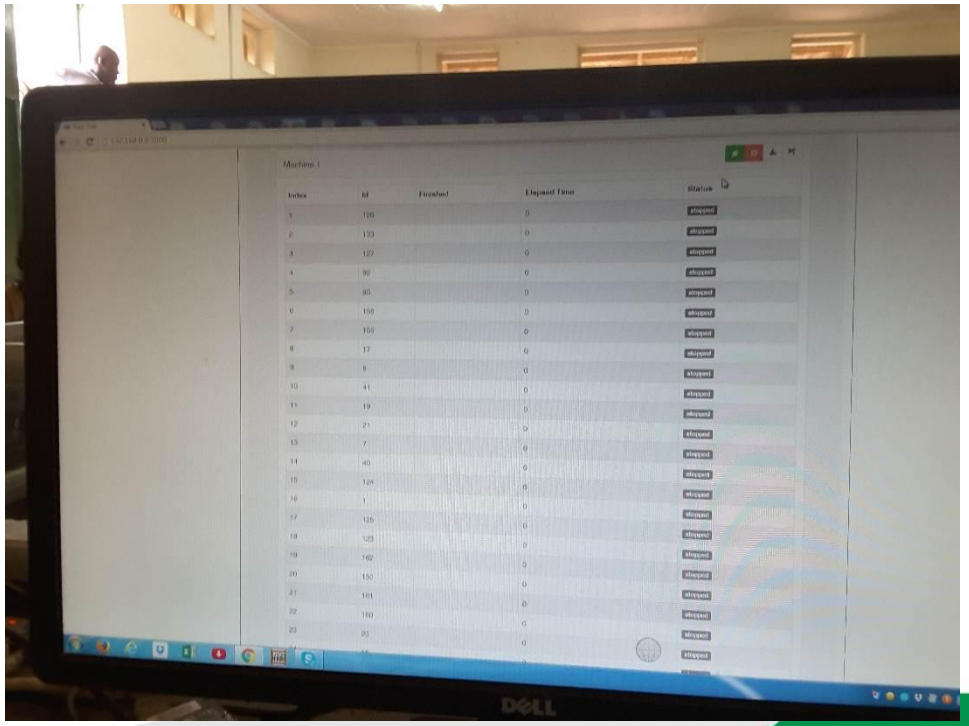
| Finding | Recommendation | Action |
| --- | --- | --- |
| **A growth chamber has previously been proposed, but has not yet been approved. It would be used primarily for pathology.**  | None | A temperature controlled foliar disease screening chamber has been installed.   |

| Findings | Recommendations | Action |
|---|---|---|
| **The use of molecular markers currently (2000 samples annually) is too low to have a significant impact. These current labs are very good, but samples currently analyzed by electrophoresis are scored manually.** | The plans are to sample approximately 30,000 per year in 2018. Lab space is adequate, but robotized sample handling would be needed. Kawanda should switch to modern technologies with automated reading capabilities (Chip).<br><br>Kawanda could be a regional hub, including other species. All released varieties need to have a high density fingerprint (not done at present). | GBS-Cornell University<br>IGSS-Beca<br>Eshires Lab<br>SNP genotyping-KBioscience UK<br>Common genotyping facility for the CGIAR<br>  <br>  |

| Finding | Recommendation | Action |
|---|---|---|
| **Drought is a major focus of dry beans in ESA but there is no one leading these efforts. There is too much rainfall in Kawanda to be a useful location for these studies.** | A physiologist is needed for drought studies for an as yet undetermined location in ESA.<br><br>Two rainout shelters are needed: 15 x 30 m for each. | Drought trials being conducted off season but surprise showers are very common making this inadequate<br><br>Irrigation facility installed<br><br>Solar system in process<br><br>Drought site being sought: requires man power |

# Additional facilities since BPAT

## Cooking time



# Phenotyping canning quality-Adapted from MSU protocol

Dry bean (non more than 3 months harvested)

Cooling – Room Temperature

Hot soaked: 30 min at 87ºC

- Submersion for 5 min.
- Removed from cool water.
- Drained before weight

Transfer contents of bag into Jars can

Add boilling brine solutions, leaving 1-inch headspace

Stack can uniformly in the basket and Autoclave for 30 minutes at 121°C.

**STORE 4 WEEKS MINIMUM AT ROOM TEMPETURE**

- 30 min at 87 °C

# Phenotyping Common Beans for Symbiotic Nitrogen Fixation (SNF):Protocol for field evaluation


# Wish: Micronutrient analysis

**X-ray florescence spectrometry (XRF)**


**Inductively coupled plasma spectrometry (ICP)**

# Support to NARS

- Germplasm
- Training
- Project collaboration
- Backstopping

**Nurseries distributed from CIAT-Kawanda Gene bank 2017/2018**

1. Drought lines: Zimbabwe, Rwanda, Tanzania, Congo, Ethiopia, NaCCRI, Senegal.
2. Yellow Bean Collection: Karen Cichy (MSU)
3. TL3 reference finger printing set (230) : Tim Porch (Puerto Rico)
4. Nutritional lines : Zimbabwe, Rwanda, Tanzania, Congo, Ethiopia, NaCCRI, Senegal.
5. DNA finger printing Panel: IGSS/ BECA Kenya
6. KFRR nursery to NaCCRI.
7. Nutritional Climbers: SARI, MARI, ARI-Uyole. KARLO Kenya
8. NUA lines to Ethiopia.
9. Bruchid resistance populations: Ethiopia Tigist.
10. Drought, and low soil fertility lines: Ghana
11. Heat stress tolerance lines: Ethiopia, Ghana, Tanzania, NaCRRI
12. CBB, Nutritional, drought Populations to MSU.

Nurseries received at the CIAT-Kawanda Gene bank 2017/2018;

1. Rust differentials from University of Embu Kenya
2. Nutritional, drought, heat, ALS nurseries from Cali Colombia.
3. SNAP Bean panel from Oregon state university.

# Challenges

- Uncertain funding to warrant increase of breeding program
- Inadequate characterization of testing sites
- Limited atomization of breeding activities
- Uneven fields: requires major effort in levelling
- Limited staffing
  - Data management support (including statistical support)
  - Engineering support to help with agricultural equipment and facility design
  - Physiology support
  - Breeding support to target specific pipelines

CIAT

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CGIAR

A CGIAR Research Center

Headquarters
Km 17 Recta Cali-Palmira C.P. 763537
P.O. Box 6713, Cali, Colombia
Phone: +57 2 445 0000

ciat@cgiar.org
**www.ciat.cgiar.org**

ciat.ecoefficient
@ciat_cgiar
@CIAT_